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(12) EUROPEAN PATENT APPLICATION

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(54) Laser interferometer system and method for monitoring and controlling IC processing.

(57) A laser end point detector incorporating adjustable-focus, variable-orientation detection optics for monitoring different types of structures such as laser-transparent thin films, isolated trenches or holes and patterned arrays of trenches or holes. A collector lens package comprising a laser and a focusing lens are mounted in a hole in a collector lens which is pivotally mounted for selectively focusing zero, first and higher orders of diffractions reflected from the wafer onto an associated detector to monitor the etching of different types of structures. For example, zero order diffraction signals are used to monitor the etching of large target areas in transparent thin films or of non-patterned trenches of holes. First order (or higher) diffraction signals are used for monitoring the etching of patterned features which effect a two-dimensional diffraction grating, such as the capacitor holes in dynamic random access memories.

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different types of etched structures; and

FIG. 6 schematically depicts the diffraction grating effect of trenches or holes.

Detailed Description of the Preferred Embodiment(s)

FIG. 3 schematically depicts a preferred embodiment 20 of our laser end point detector, which includes a moving carriage or stage 25 mounted on a semiconductor processing reactor system 26. The carriage 25 supports the entire laser detector optics system 30 which is used to monitor the etching of workpieces such as wafer 27 via window 28 in chamber wall 29. One such reactor system 26 is disclosed in co-pending, commonly assigned U.S. patent application, Serial No. 185,215, filed April 25, 1988, in the name of Cheng et al, which application is hereby incorporated by reference in its entirety.

In its present version, the stage 25 comprises a base plate 31 slidably mounted along rails 32 for reciprocal movement along the wall 29 and window 28 by a stepper motor 33-driven lead screw 34. (The center section of the rail 32 is deleted in FIG. 3 to more clearly illustrate lens 38.)

The laser optics system 30 includes a laser pen which comprises a diode laser 36 and an associated focusing lens 37, both of which are mounted in a central aperture 51 within a collector lens 38. A photodetector 39 is mounted on a second, elevated platform or plate 41 which is supported by posts 42. The platform 41 can be raised or lowered along posts 42 to select the reflected diffraction order. The collector lens 38 is supported by a kinematic mount comprising a plate 56 which supports the collector lens 38 and which is supported on three adjustment screws 57 threaded into base plate 31 and journaled between the screw heads and compression springs 58. Adjustment of the screws affords pivotal or tilting movement of the lens 38, e.g., about associated axes in the plane of the base plate 31.

A standard personal computer 47 such as the IBM AT is interfaced with the detector 39, stepper motor 33, and associated power supplies in a conventional manner for controlling operation of the photodetector 39, scanning of the stage 25 and analysis of the output signal from the photodetector 39 for terminating (and starting, if desired) the etch process. Visual readout 48 at a display device 49 such as a printer and/or monitor provides comprehensive graphics, plots, records of input data, filtered data, etched depth, etch rate, etc., as desired.

The orientation of the pivotal collector lens 38 relative to the planar workpiece 27 by the kinematic mount selects the diffraction order directed onto the detector 39 by the collector lens according to the type of target structure being etched.

For example, many semiconductor structures contain a pattern of etched features which act like a two-dimensional diffraction grating. This includes VLSI dynamic random access memories (DRAM's) in which bit storage is in capacitors formed in micron and sub-micron size holes arranged in a grid pattern, one hole per cell. Illustratively, for a sixteen megabit chip there are sixteen million holes on the chip which form a very regular, simple grid pattern which can be used as a two-dimensional diffraction grating for first and higher orders or diffraction. See FIG. 6. To monitor the etching of such holes, the lens 37 is used to focus the laser light to a wide area on the target 27. Also, as shown in FIG. 4, the collector lens 38 is oriented so that first order diffraction light (designated 53 in FIG. 4) or higher ordered diffractions in all directions (collectively designated 54) is collected by the collector lens onto the photodetector 39. Specifically, in FIG. 4 the collector lens is oriented with its axis substantially perpendicular to the normal to the plane of the wafer 27. First order diffraction is usually preferred over higher orders because of its higher intensity. The etch fabrication process generates an output trace of the type 48 as shown in FIG. 3, for determining the distance etched and etch rate.

For etch monitoring and end point detection of thin films, such as those depicted in FIG. 1, whose features do not form a diffraction grating, zero order diffraction is used during monitoring. As shown in FIG. 5, the pivotable collector lens 38 is oriented at a small angle relative to the orientation of FIG. 4 so that zero order diffraction light 55 is incident on detector 39, and the lens 37 is used to focus the laser light 52 sharply onto the wafer 27. Again, the etch fabrication process generates an output trace of the type 48 as shown in FIG. 3 for determining dimension etched, etch rate and end point.

In short, to provide maximum signal strength monitoring of patterned etched features such as holes or trenches, preferably a relatively wide area beam spot is used and the collector lens assembly is oriented so that the first order diffraction light is directed to the detector. To monitor features which do not form a diffraction pattern, such as transparent dielectric films or non-patterned holes or trenches, the light is sharply focused to a relatively small area on the substrate 27 to minimize the wafer area illuminated by the laser and the collector assembly is oriented so that zero order diffraction light is detected by the detector 39.

In a working embodiment, our laser end point detector system was mounted on a Precision Etch

layer so that the laser light is reflected off the substrate layer at a selected orientation relative to the substrate and to a light detector so that a selected diffraction order of light is incident on said detector; and converting the resulting optical interference signal into a corresponding electrical signal for monitoring the fabrication process.

6. The method of Claim 5, wherein the target area on the substrate is selected from (1) material which is transparent to the laser light and a hole being etched in the substrate and (2) a pattern of etched features serving as a two-dimension diffraction grating to said incident laser light and wherein said selected diffraction order is, respectively, (1) the zero order and (2) a first or higher order.

FIG. 4

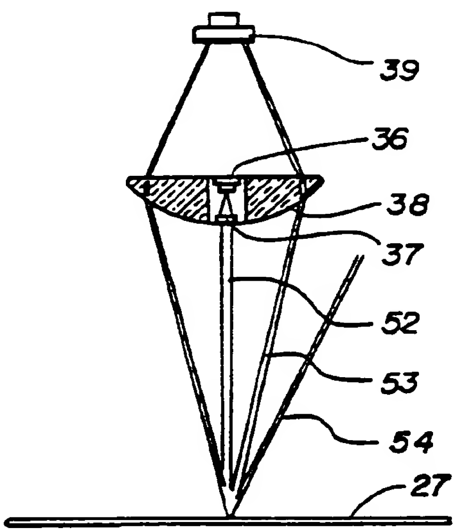
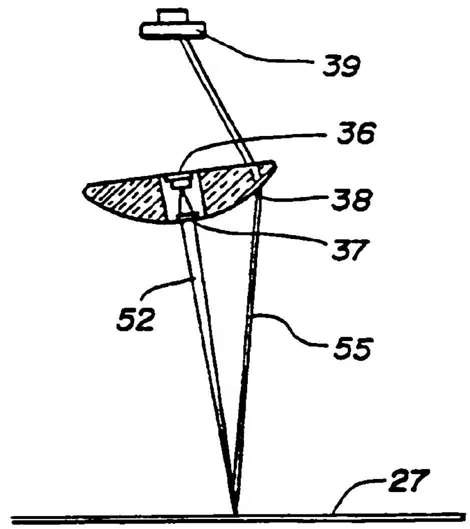


FIG. 5



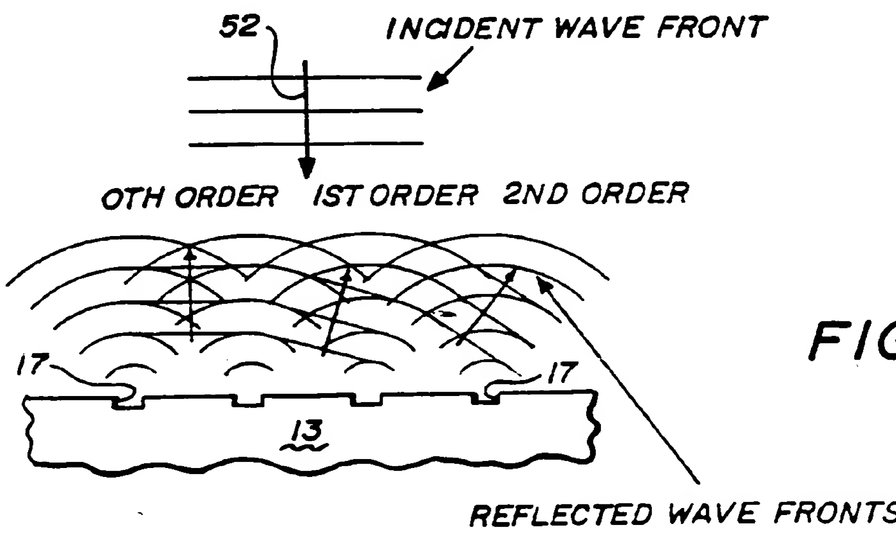


FIG. 6

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Europäisches Patentamt
Zweigstelle in Den Haag
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Datum/Date

Zeichen/Ref./Réf.	Anmeldung Nr./Application No./Demande n°//Patent Nr./Patent No./Brevet n°
45883000/EA5585	96302176.1 - -

Anmelder/Applicant/Demandeur//Patentinhaber/Proprietor/Titulaire
APPLIED MATERIALS, INC.

COMMUNICATION

The European Patent Office herewith transmits

- [X] the European search report
- [ ] the declaration under Rule 45 EPC
- [ ] the partial European search report under Rule 45 EPC
- [ ] the supplementary European search report concerning the international application under Article 157(2) EPC

relating to the above-mentioned European patent application. Copies of the documents cited in the search report are enclosed.

The following specifications given by the applicant have been approved by the Search Division :

- [X] Abstract
- [X] Title
- [ ] Figure

- [ ] The abstract was modified by the Search Division and the definitive text is attached to this communication.
- [ ] The following figure will be published with the abstract, since the Search Division considers that it better characterises the invention than the one indicated by the applicant.

Figure:

- [X] Additional copy(copies) of the documents cited in the European search report.

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REFUND OF THE SEARCH FEE

If applicable under Article 10 Rules relating to fees, a separate communication from the Receiving Section on the refund of the search fee will be sent later.

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 96 30 2176

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
P,X	EP-A-0 663 265 (IBM) 19 July 1995 * the whole document * ---	1-42	B24B37/04 B24B47/12 B24D7/12 G01B11/06
Y	EP-A-0 352 740 (APPLIED MATERIALS INC) 31 January 1990 * abstract * ---	1,12,21,30,39,42	
Y	FR-A-1 075 634 (HANS GÜNTHER LUX) 19 October 1954 * page 2; figures * ---	1,12,21,30,39,42	
A	US-A-4 948 259 (ENKE KNUT & AL) 14 August 1990 * abstract; figure 3 * ---	1,12,21,30,39,41,42	
A	US-A-5 081 796 (SCHULTZ LAURENCE D) 21 January 1992 * abstract * -----	1,30,39,42	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

B24B
B24D
G01B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	31 July 1996	Eschbach, D

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 96 30 2176

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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31-07-1996

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
EP-A-0663265	19-07-95	US-A-	5433651	18-07-95
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		US-E-	RE34425	02-11-93

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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FIG. 4

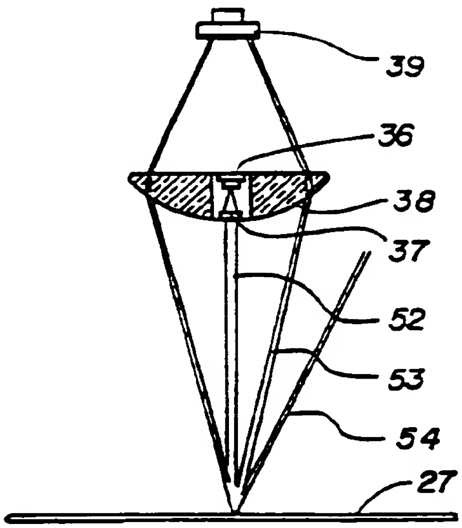
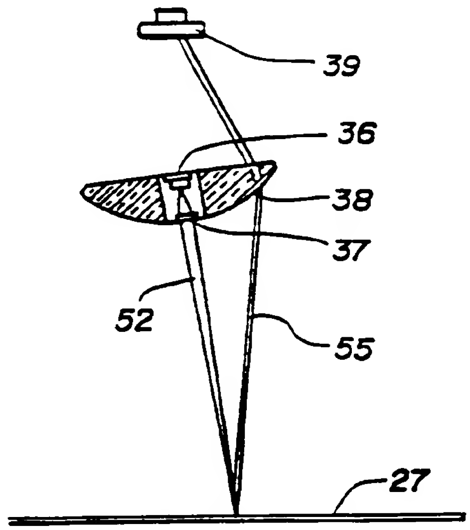


FIG. 5



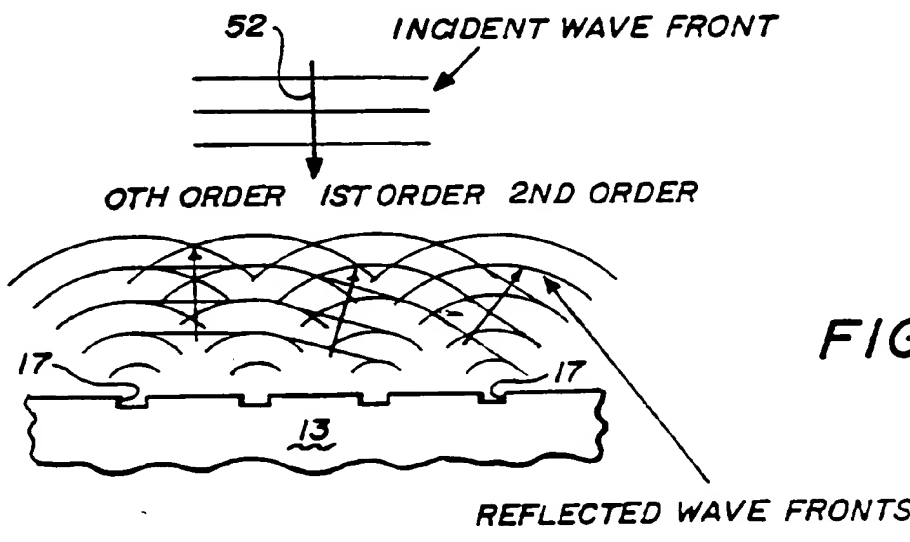


FIG. 6